Exam
Thermal Energy Conversion (SEE020)

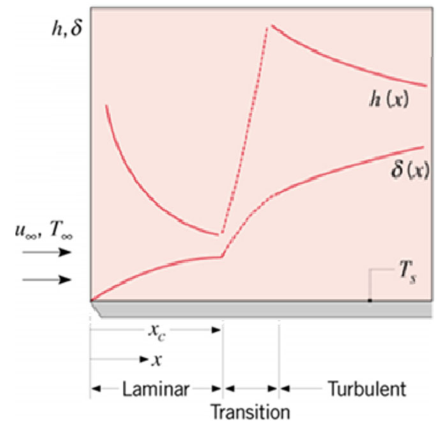
2022-04-13, 14:00 - 18:00

Examiner	David Pallarès (tel. 031 772 1435)
Exam review	week 17 (after agreement via e-mail: david.pallares@chalmers.se)
Allowed resources:	calculator, course book
Mark scale	Mark 5: at least 24 p Mark 4: at least 18 p Mark 3: at least 12 p Not passed: less than 12p

1. Describe under which circumstances coal combustion is: a) renewable, and b) sustainable. (2p)

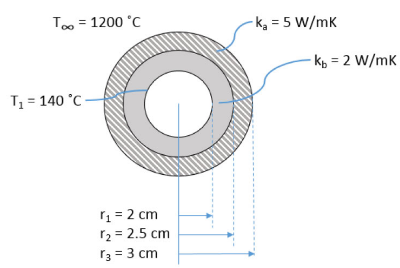
2. The following plot illustrates how the heat transfer coefficient between a plate and a fluid, *h*, develops with length along the plate, *x*. Explain: (4p)

a) why is the heat transfer coefficient decreasing with length in the laminar region?
b) why is the heat transfer coefficient suddenly increasing in the transition from laminar to turbulent flow?
c) why is the heat transfer coefficient decreasing with length in the turbulent region?
d) what is the laminar sublayer?



3. A biooil flows inside two concentric tubes placed in an oven providing a surrounding (both the gas and the oven inner walls) at 1200 °C. In a certain location, the biooil is at 140 °C. In this location, the convective and radiative heat transfer coefficients at the outside of the outer tube are h_{conv} = 13 W/m²K and h_{rad} = 54 W/m²K, respectively. Dimensions and properties of the tubes are given in the figure below.

a) What is the heat *q* [W], received by the biooil along 1 cm of tube in this location? (2p)
b) What are the temperatures in this location at the surface of the outer tube and in the interface between the two tubes? (3p)



4. Energy systems characterized by fluctuating energy flows can have a more stable operation by being equipped with energy storage tanks. A filled, well-mixed cylindrical tank (r = 5m, h = 15m) stores water (C_p=4500 J/kgK, ρ=950 kg/m³) at 85 °C. The heat losses from the water tank to the surroundings (which maintain 5 °C) can be described by a thermal resistance, R=$2\cdot10^{-4}$ K/W. The water in the tank begins to be replaced by an incoming flow (1.5 m³/s) of water at 60 °C.

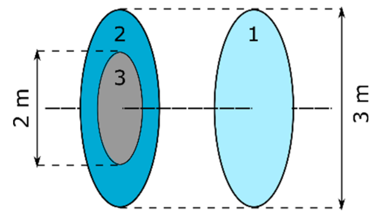
a) Calculate the tank temperature after one hour. (3p)
b) Do you consider this tank to be well-dimensioned for acting as a dampener of temperature flucutations in the system? (1p)

5. Two coaxial discs are directed towards each other in accordance with the figure below. The distance between the discs is 2 m and the left disc consists of the two segments, 2 and 3. Disc 1 can be assumed to be a blackbody with a temperature of 400°C. If the view factors F_{13} & $F_{1(2+3)}$ are given as $0{,}14$ and $0{,}29$ respectively, calculate:

a) the view factors F_{12} & F_{21} (1p)

b) the emissive power from disc 1 reaching disc segment 3, that is $q_{1\rightarrow 3}$ (1p)

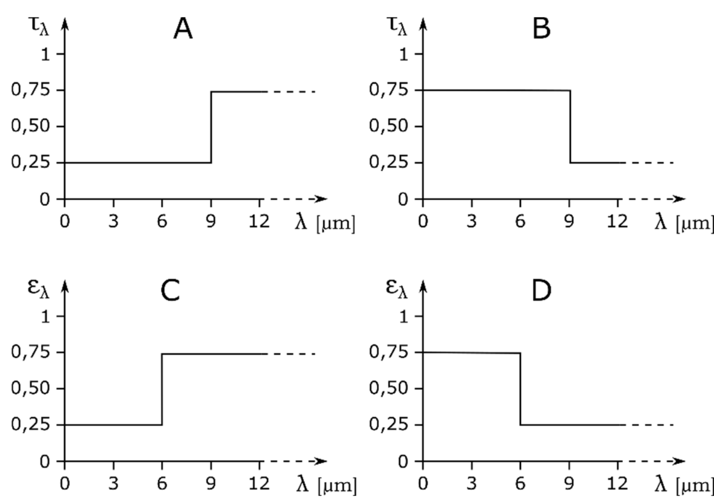
c) the amount of $q_{1\rightarrow 3}$ being absorbed, reflected, and transmitted at disc segment 3, if disc segment 3 is an opaque material with an emissivity of 0,40. (1p)



6. As a hobby project, you have decided to build yourself a thermal solar collector. You are at the stage where you must select what materials to use for the glass lid and the absorbing plate. You have found two options of each that are economically appealing.

a) Based on the transmissivities of the glass options (A-B) and the emissivity of the absorbing plate material options (C-D), given in the figures below, which glass option and what absorbing plate material should you choose to build the most efficient thermal solar collector? Motivate your choices. **(2p)**

b) Calculate the *total emissivity* and *the total absorptivity* for the absorbing material you selected in a) if your absorbing plate reaches a temperature of 200°C. You may assume the sun to be a blackbody at 5800K. **(4p)**
(If you did not select any option in a), you may perform your calculations for either material C or D).



7. You are overseeing the heat exchanger network of a chemical production site and look for options to improve the performance without replacing the existing heat exchangers. You identify the most relevant heat exchanger being a parallel tube heat exchanger meant to cool the product stream.

a) Calculate the effectiveness and the overall heat transfer coefficient U based on the following data **(2p)**

	$\dot{m}$ **[kg/s]**	C_p **[J/kgK]**	T_{in} **[°C]**	T_{out} **[°C]**
cold (water)	25	4200	12	65
hot (product)	25	3212	150	80,7

A=58m²

b) What options do you see to increase the effectiveness without replacing the heat exchanger? What to consider for the different options? **(2p)**

c) Which option would you choose (motivate)? Calculate the new effectiveness and outlet temperatures assuming U to remain unchanged **(2p)**